Perceiving and Behaving in a Crisis: Developing a Multi-Functional Crisis Information Platform for Psychosocial Situations (CIP-PS)

Sebastian Sterl
Technische Universitaet Braunschweig
sebastian.sterl@tu-braunschweig.de

Andreas Billig
Fraunhofer Institute for Open Communication Systems
andreas.billig@fokus.fraunhofer.de

Franck William Taffo
Fraunhofer Institute for Open Communication Systems
franck.william.taffo@fokus.fraunhofer.de

David Svoboda
Fraunhofer Institute for Open Communication Systems
david.svoboda@fokus.fraunhofer.de

Lars Gerhold
Technische Universitaet Braunschweig
lars.gerhold@tu-braunschweig.de

ABSTRACT

Increasingly long-lasting and complex crises and disasters can cause psychosocial effects on certain population groups with different vulnerabilities. To increase a population's resilience, it is necessary to examine these effects more deeply by systematically monitoring the psychosocial situation, integrating different types of data and making this data researchable, visible, and documentable via a multi-modal platform. Following a systems thinking approach, this paper presents a full approach to developing a "Multi-Functional Crisis Information Platform for Psychosocial Situations" (CIP-PS) for Germany, which includes the integration of an ontology- and filter-based research component (CIP-REP), a filter-based dashboard component (CIP-DAB), and a documentation component (CIP-DOC) into a complete information platform. In sum, this platform fulfills the requirement of comprehensively integrating different psychosocial data (e.g., survey, meta data, or question item data) into a system capable of fully linking all components and related data to healthcare informatics.

Keywords

Crisis information platform, psychosocial situation, data integration and visualization, dashboard and research platform, vulnerabilities

INTRODUCTION

The number of crises and disasters – such as, e.g., the Corona pandemic or extreme weather events – are increasing worldwide (Boin, 2019), posing risks and threats to the population (e.g., Munich Security Conference, 2023). When crises become more long-lasting, complex, intertwined, or transboundary (Boin, 2019), negative *psychosocial consequences* can emerge, such as post-traumatic stress disorder (PTSD), anxiety, or depression related to crises or disasters, which differ in relation to the vulnerabilities (*risk factors*) in certain population groups (Bonanno et al., 2010). This means that not only the physical condition of people affected by crisis or disaster is important when monitoring their effects. In coronavirus crisis management, for instance, psychosocial experts address the psychosocial situation of the population in addition to virological concerns (Hering et al., 2021), so as to increase the population's (psychosocial) resilience in times of crisis and disaster.

The main goal is thus to increase the population's resilience. Resilience is defined as a system's or an individual's ability to manage changes and continue developing (Moberg & Simonsen, 2011). The rise in complex and systemic crises leads us to take the approach of systems thinking: we understand society as a complex adaptive system (Carvalhaes et al., 2021) in which every stakeholder contributes to crisis preparation. This holistic approach is called the "system of systems" thinking (Cavallo, 2014). Additionally, Carvalhaes et al. (2021) speaks of a "wicked complexity" causing deep uncertainty and requiring new approaches to understanding how society functions. In order to assess resilience, combining quantitative and qualitative methods are seen as an innovative approach (Carvalhaes et al., 2021). According to the disaster resilience approach by Cavallo (2014), it is important to create an overall perspective, including top-down and bottom-up processes for unknown risks, and to regard crises management as an all-hazard-approach (Carvalhaes et al., 2021) to widen the situation picture, detect signals and see the bigger picture which is important to cope with the crisis (Leidner et al., 2009). Also, a shared understanding of the situation among all stakeholders as well as a modularization for software reuse is important for coordinating response activities and making it possible to reuse software in future projects (Leidner et al., 2009). This requires both a common knowledge base of psychosocial terms and situation definitions and a platform using individual components that can function alone and be applied in other crisis contexts. Furthermore, given the increasing importance of knowledge transfer, scientific knowledge should be prepared for target groups and co-developed in common projects aimed at actionable knowledge tailored to the needs of particular groups (Treffeisen & Grosfeld, 2022). Standards of transparency and verifiability ensure that society can trust this knowledge, which can be distributed on service platforms for the stakeholders concerned (Treffeisen & Grosfeld, 2022).

This raises the main research question:

> *How can an information platform contribute to increasing the population's (psychosocial) resilience in times of crisis and disaster?*

When appealing to the ability and resilience of citizens as their own crisis managers (see Boin, 2019), *individual resources* as well as the *perception* of and *behavior* in different crises should be monitored to derive suitable risk or crisis communication strategies to cope a crisis[1]. Also, other psychosocial information sources such as studies on help-seeking behavior in crises or field protocols on psychosocial emergency care have to be integrated into a system that monitors the overall psychosocial situation of the population at large as well as of those directly affected. Therefore, these different data concerning psychosocial topics should be combined in an information tool that makes them systematically researchable, visible, and documentable. That is, survey-based psychosocial situation pictures of the population as well as information on help-seeking behavior and psychosocial emergency care in times of crisis and disaster must be harmonized and fed into a platform targeting crisis managers as well as (government) decision-makers and authorities, the scientific and media community, and the public at large. This platform should be able to handle different psychosocial topics and related data accessed in different components depending on what the user is interested in. It must allow for an efficient and quick access to the components requested.

[1] We define the psychosocial situation picture using five psychosocial categories: perception (e.g., risk perception), behavior (e.g., protection behavior), risk factors (e.g., age) as well as resources (e.g., resilience) and psychosocial consequences (e.g., stress) (Gerhold et al., 2022; Lüttschwager et al., 2022).

This raises the more technical question:

> *How should an information platform be technically constructed so as to integrate different data types and connect different components with one another?*

Information, research, or dashboard platforms that collect and present various data in crises, disasters, or more general contexts do exist. While entire information platforms such as INFORM (European Commission - Disaster Risk Management Knowledge Centre [EC-DRMKC], 2023) or dashboards such as the Natural Disasters Dashboard (Office for the Coordination of Humanitarian Affairs [OCHA], 2023) use statistical or process data, only few information or dashboard platforms use survey data like the Smart Data Disaster Management (Smart Data, 2023) or PACE (University of Erfurt et al., 2023). Research platforms with functionalities similar to ours are rare. They include the IFRC GO (Red Cross Red Crescent [IFRC], 2023) for disasters in general or the paneldata.org-explorer (German Socio-economic Panel [GSOEP], 2023) in generic contexts using statistical/process or survey data, among others.

To the best of our knowledge, there are to date no information platforms combining survey, systematic review, and psychosocial emergency care data.

In terms of application, the question becomes:

> *How can different data be integrated and aggregated into a tool that researches, visualizes, and documents them?*

We answer these research questions by first explaining our research methodology, then reviewing the current research, including an overview of existing information, research, and dashboard platforms, before showing in greater detail how we developed the "Multi-Functional Crisis Information Platform for Psychosocial Situations" (CIP-PS). Therefore, we explain the overall structure and outline the data used for integration into the entire system. Next, we describe the single elements of the research component CIP-REP, the dashboard component CIP-DAB, and the documentation component CIP-DOC, including their technical and visual implementation and how they link to one another. We then present different use cases for CIP-REP and CIP-DAB in different scenarios. The final sections discuss challenges and limitations, followed by a conclusion and future steps.

RESEARCH METHODOLOGY

In this section, we explain our research methodology, following those in information systems (IS) summarized in Kilani and Kobziev (2016) and the design science research[2] IS framework by Peffers et al. (2007). First, we defined the problem as a lack of information platforms providing information on the psychosocial situation in crises using state-of-the-art research. We addressed this in several research steps, such as tool programming and data collection/processing, development, and prototyping (Archer, 1984). In general, we followed a two-stage approach, by looking at CIP-PS as a whole (stage 1) and then its components CIP-REP, CIP-DAB, and CIP-DOC (stage 2), using both a qualitative and a quantitative approach.

In stage 1, we exploratively developed CIP-PS by means of data collection steps such as state-of-the-art research on established information platforms (see below), and a target group analysis (with our project partner from the German Red Cross as the first target group). Next, we created an overview of the psychosocial topics and conducted further group interviews with aid organization members in order to explore the potential use of our platform. Our research strategy entailed multiple use cases (shown below), addressing precise potential problems, target groups, and processes. The (technical) validity and reliability of the platform was ensured by applying scientific standards and established solutions of User Interface (UI) and User Experience (UX) research in its development. Components from other projects were reused to create synergy effects. CIP-PS systematically presents psychosocial topics in order to illustrate the complex psychosocial crisis situation and reduce complexity in a model that can be analyzed and that explains the situation and its interdependencies in an understandable and transparent way. This serves target groups as a decision support system and improves individual resilience, the core purpose of CIP-PS (as set forth in the Introduction).

In stage 2, the different components as a "system of systems" (see above) are treated with different sub-methodologies.

CIP-REP follows a qualitative approach by integrating results of documents and study outcomes using meta-

[2] Simon (1969, p. 55) as cited in Peffers et al. (2007) stated, that "[w]hereas natural sciences and social sciences try to understand reality, design science attempts to create things that serve human purposes".

analysis and the qualitative content analysis research strategy (Mayring, 2015). The terms of these documents were deductively derived into ontologies, filters, and contents and can be inductively expanded with new concepts.

CIP-DAB, by contrast, follows a quantitative research strategy using quantitative data on surveys and protocols, which are deduced from the framework of psychosocial situation research (e.g., Gerhold et al., 2022) and represented in validated and reliable question constructs. These are presented in a statistically reproducible and clear way (e.g., plots) differentiated by scientifically derived risk factors.

Finally, CIP-DOC applies scientific principles of transparency and documentability to both components by storing easily accessible documentation of studies, questionnaires, and protocols.

STATE OF THE ART AND RELATED WORK

We define an information platform as a "software-based platform" and core functionality with different modules as software subsystems which can then "extend the functionality of the platform" (Hein et al., 2020, p. 88). The information platform as an overall framework embeds sub-systems such as CIP-REP as well as CIP-DAB. CIP-REP is an IR (Information Retrieval)-based component for semantics-enabled searches of project artifacts, whereas a dashboard is a visualization "of a consolidated set of data for a certain purpose" (Matheus et al., 2020, p. 1) with different types of presentations, such as geographic, numerical, or temporal (Schulze et al., 2023).

Table 1 illustrates some examples of information platforms like the INFORM (EC-DRMKC, 2023), HEIMDALL (German Aerospace Center [DLR], 2021), or the Global Crisis Response Platform (International Organization for Migration [IOM], 2023) that integrate different elements and crisis-related data into one platform. Research platforms such as the IFRC GO (IFRC, 2023) or Google Crisis Response (Google, 2023) allow users to systematically research the data that is also presented visually, while general research platforms such as paneldata.org (GSOEP, 2023) enable the user to search for survey variables similar to our CIP-REP component with its psychosocial situation monitoring survey data. In terms of dashboards, there are examples of tools integrating survey data, such as the PACE project (University of Erfurt et al., 2023) or the Covid-19 National Survey Dashboard (CAMH, 2023), with many others visualizing statistical or process data on the environment, natural disasters, or crises in general (e.g., Community Risk Assessment: Netherlands Red Cross, 2023; Natural Disasters Dashboard: OCHA, 2023; Global Crisis Risk Dashboards: United Nations Development Programme, 2020). Another selection of dashboards can be found in Sterl et al. (2023) or, for public health data, in Schulze et al. (2023).

Table 1. Examples of information platforms (MIP), research platforms (REP), and dashboards (DAB)

Type of platform	Type of crisis	Type of data	Specific content	Example of tool (Citation)
MIP	Environment/climate/humanitarian crises	Statistical/process	Information about crises in general (focus on, e.g., risks, warnings, climate change)	INFORM (EC-DRMKC, 2023)
	Natural disasters	Statistical/process	Disaster-relevant information	HEIMDALL (DLR, 2021)
	Medical crises	Statistical/process	Information about coordination and decision processes (concerning crises/medical emergencies)	COncORDE – Crisis Management Platform (Konnektable Technologies, 2021)
	General disasters	Statistical/process/survey	Real-time data on crisis-relevant information (e.g., water levels, stress levels, social	sd-kama (Smart Data, 2023)

			network structure)	
	General crises	Statistical/process	Crises-relevant information	Global Crisis Response Platform (IOM, 2023)
REP/DAB	Disasters in general	Statistical/process	Disaster-relevant information	IFRC GO (IFRC, 2023)
	General crises	Statistical/process	Crises-relevant information	Google Crisis Response (Google, 2023)
REP	General	Statistical/process/survey	Information on, e.g., research data	paneldata.org (GSOEP, 2023)
	General	Statistical/process/survey	Information on, e.g., research data	GESIS search (GESIS - Leibniz Institute for the Social Sciences, 2023)
DAB	Covid-19	Survey	Covid-19 information (main focus on the mental health and substance use in Canadian population)	COVID-19 National Survey Dashboard (CAMH, 2023)
	Environment/climate crisis	Survey	Information about the climate crisis (focus on, e.g., attitudes, behavior, risk perception)	PACE Explorer (University of Erfurt et al., 2023)
	Environment/climate/ humanitarian crises	Statistical/process	Information about affected areas in humanitarian crises	Community Risk Assessment (Netherlands Red Cross, 2023)
	Natural disasters	Statistical/process	Disaster-relevant information	Natural Disasters Dashboard (OCHA, 2023)
	Ukraine crisis	Survey	Information about the Ukraine crisis	GeoPoll Ukraine Crisis Data Tracker (GeoPoll, 2022)
	General crises	Statistical/process	Information on global risks	Global Crisis Risk Dashboards (United Nations Development Programme, 2020)
	General crises	Statistical/process	Crises-relevant information (e.g., geographical,	The Emergency Dashboard (World Food Programme,

		funding, and performance-related information)	2023)

Note: This represents only a small sample. Another selection can be found in Sterl et al. (2023); a much wider selection can be requested from the authors of this paper.

In sum, there are many platforms and components that focus on crises, disasters, or general events. However, most tools primarily integrate process-produced information instead of population surveys, literature reviews of scientific studies, or information on psychosocial emergency care that would present an overall picture of the psychosocial situation in times of crisis and disaster.

To explore the information items concerning survey and statistical data, mature techniques can provide adequate means for a broad range of target users.

The approaches presented here focus on the integration of three diverse, almost independent views (see Sterl et al., 2023):

1) Research and exploration offering an interface for the semantic retrieval of domain-relevant data
2) Statistical interdependencies with CIP-DAB utilizing enhanced visualization techniques for statistical data
3) Documentation library, inspecting static, document-oriented artifacts

Given the above, we see two gaps in the research:

First, based on the systems thinking approach and the knowledge transfer paradigm, we bring together different data on psychosocial topics into one platform to reduce complexity, and to help users systematically research, visualize, and document all the data in a way that is tailored to their needs and addresses the main goal of increasing resilience in the population.

Next, our IS fully connects not only a dashboard visualization component but also a research and documentation component in the front as well as backend layer to help the users visualize the information required for their decisions.

We conclude that the development of CIP-PS is – to the best of our knowledge – innovative and fills in the research gaps we noted above. The next sections present in greater detail the overall structure of CIP-PS as well as its single components CIP-REP, CIP-DAB, and CIP-DOC.

DEVELOPING THE CRISIS INFORMATION PLATFORM CIP-PS

General Concept

CIP-PS is divided into three different layers, including the psychosocial topics: “Psychosocial situation in Germany” (PSG), “Help-seeking behavior” (HSB), and “Psychosocial emergency care” (PEC) (*Figure 1*). Depending on what topic the user selects, the respective CIP-REP, CIP-DAP, or CIP-DOC opens. For both PSG and PEC, CIP-REP, CIP-DAB, and CIP-DOC are displayed, while for HSB, CIP-REP and CIP-DOC are shown. Further, descriptions of each psychosocial topic are shown after clicking on the appropriate information text section.

The overall platform design is structured as a micro frontend. That is, CIP-REP, CIP-DAB, and CIP-DOC are micro frontends independent of each other and linked via an integration layer. The complete frontend is composed of different, independently working components. The data which is called up by the user is pre-processed using a proxy server and then integrated into a data format representing the specific characteristics of every frontend. CIP-REP, CIP-DAB, and CIP-DOC can be deployed singularly regarding the other elements, while CIP-PS is highly responsive and restricted to tablet mode following the principles of high UI/UX standards using the bootstrap 4 library with their own guidelines (Bootstrap, 2023). Regarding app functionality, the CIP-PS is designed as a Progressive Web App (PWA; Tandel & Jamadar, 2018) working offline. This means that it loads all the required data when it is first established or called up by the user, and thus runs much more quickly in subsequent single uses. The data required in the respective component is saved in the background so that the user can keep researching free from interference. Since a PWA also works offline running directly on the device, the CIP-PS can be used without an Internet connection.

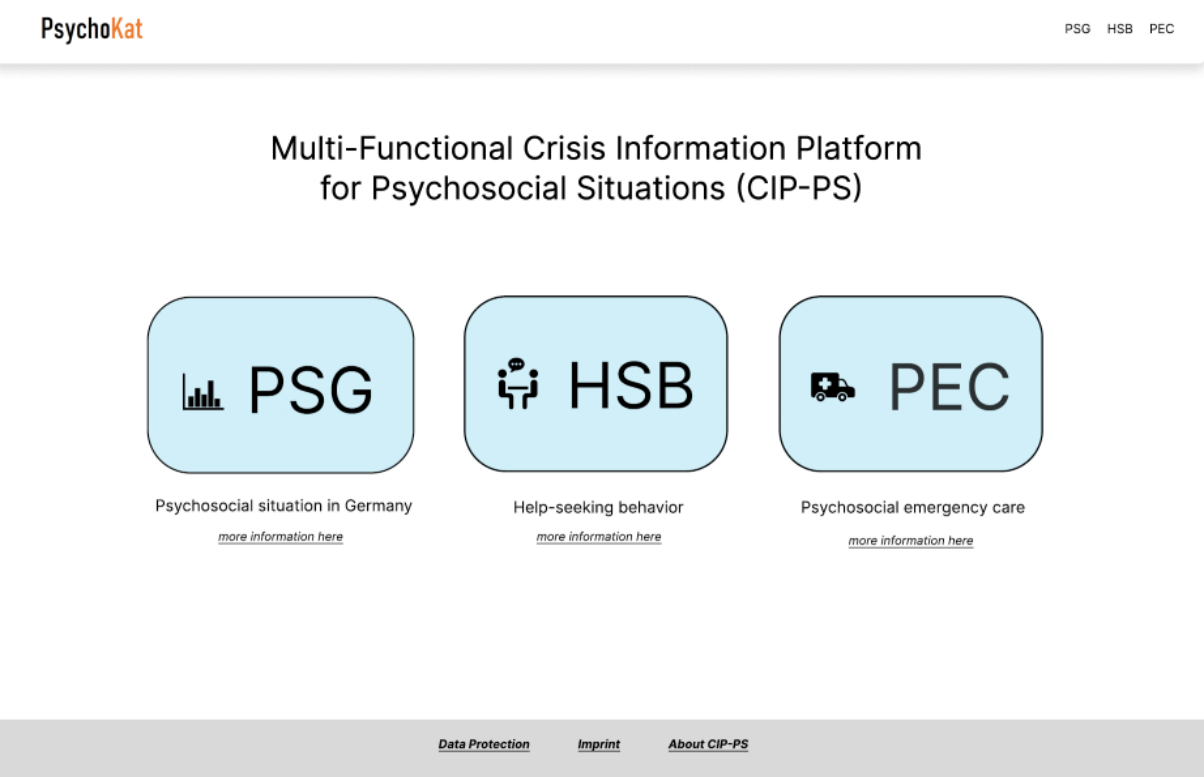

Figure 1. Screenshot of the overall structure of CIP-PS

Research Component: CIP-REP

CIP-REP is dynamic and includes filter- as well as ontology-based research on PSG, HSB, and PEC (see *Table 2* and *Figure 2* below). For PSG, data includes questionnaires, codebooks, as well as descriptive statistics of both the national and model regions per survey wave. Users can search psychosocial variables using the search field or a topic or word cloud. As a result, for instance, variable names, questions, and value labels as well as descriptive univariate statistics are shown in the form of an overview. For PEC, data consists of documentation (e.g., field/operation protocols, research, literature). For HSB, there are scientific studies on crises and disasters. Certain words or phrases can be used to find PEC or HSB results filtered by, e.g., year of publication or research method. Data must be uploaded manually and can be expanded with further information in the form of, e.g., questionnaires for PEG.

Table 2. Structure of CIP-REP

Psychosocial topic	1.	PSG
	2.	PEC
	3.	HSB
Integrated data by psychosocial topic	1.	Codebooks, questionnaires and descriptive calculations of national/model region surveys per survey wave
	2.	Documentation on PEC (e.g., field/operation protocols, research, literature)
	3.	Documentation on HSB in crises and disasters (e.g., individual studies)
Result displays (e.g.)	1.	Question wording, question values, type of crisis
	2.	Publication year, title, author
	3.	Publication year, research method, population group
Overall content use/data upload/data base	-	Dynamic/manual/expandable
Searches	-	Filter- and ontology-based
Additional remarks	-	Ontology representation according to SKOS standard, additional authoring component

One of the technical requirements for the multi-modality of CIP-REP is a component design which should be particularly integrative. For the core information model of CIP-REP based on the integrated data in *Table 2* (e.g., codebooks, questionnaires, or descriptive calculations), it is important to avoid duplicating shared information structures and increase and maximize the reprocessing of common structures, especially patterns. Apart from these classic data-oriented information structures, ontologies as well as the corresponding search and exploration of the underlying data are crucial attributes. Various domain ontologies, based on different data sources and represented by the SKOS standard (World Wide Web Consortium [W3C], 2012), stand for the specific vocabularies of the particular domain. The multi-ontology approach focuses on genericity in order to dynamically support exchanging domain ontologies. This can be separately applied to various domains, e.g., the medical domain (Billig & Krebs, 2014). Here we adapted mature partition techniques from Decker et al. (2005) and ontology matching techniques from Billig et al. (2007).

Dashboard Component: CIP-DAB

CIP-DAB is also structured in a dynamic and interactive way and uses filters for the psychosocial topics PSG and PEC (see *Table 3* and *Figure 3* below). For PSG, it involves longitudinal survey population data on the psychosocial situation, cross-sectional survey data on preparedness for special crises (e.g., heat, terrorist attack), and model region survey data on PEC per survey wave in Germany. The results include statistically pre-processed longitudinal data (e.g., CI-plots, bar charts) on psychosocial variables such as risk perception, protective behavior, or coping strategies collected for diverse crises (Ukraine crisis, Covid-19, climate change, or inflation) by risk factor (e.g., age or sex) or region (e.g., German states). For PEC, there is simulated data on PEC field protocols and information on PEC units of an aid organization operating in German communities, which then are displayed descriptively using univariate and bivariate statistics (e.g., bar charts or tables). Data such as survey data for PSG, for instance, must be uploaded manually but can be expanded with further information.

Table 3. Structure of CIP-DAB

Psychosocial topic	1. PSG 2. PEC
Integrated data by psychosocial topic	1. Longitudinal survey data on the psychosocial situation, cross-sectional survey data on preparedness for special crises (e.g., heat, terrorist attack), model region survey data on PEC 2. Simulation survey data on PEC field protocols, information on PEC units of aid organization in German communities
Result displays (e.g.)	1. Univariate/bivariate statistics on survey variables, risk factors, region (e.g., CI-plots, bar charts, summary) 2. Univariate/bivariate statistics on simulated variables of emergency care field protocols (e.g., CI-plots, bar charts, summary); descriptive information on PEC units
Overall content use/data upload/data base	- Dynamic/manual/expandable
Searches	- Filter-based
Additional remarks	- Contains a map, graphs, data input; uses libraries such as leaflet map, Bootstrap-select or D3.js

The dashboard consists of three main components using various libraries, for data input, map, and graph section. For the data input, five select elements were built with the Bootstrap library (Otto & Thornton, 2023). Further, using a map section, the affected regions can be displayed on a map with polygons of varying thickness. The map was implemented with Leaflet (Agafonkin, 2023) and the polygon data is provided by a GeoServer. Finally, the graphs, which serve as the main response view, were implemented separately with the D3.js library (Mike Bostock and Observable, 2023) and are added to the project via dependency injection. Some of the advantages of CIP-DAB are the ability to separately deploy the visual controls of the dashboard as well as its capacity for working with a large amount of data.

Documentation Component: CIP-DOC

CIP-DOC is a static tool for downloading information on PSG and PEC in order to quickly obtain required files (see *Table 4*). For PSG, survey information such as questionnaires, codebooks, and short descriptive reports of survey waves are integrated and downloadable in a readable and portable file format. For PEC, data comprises documentation on PEC (e.g., standardized field/operation protocols, research, literature) which can be downloaded as a ready-to-read file. Finally, all the data is uploaded manually and expandable by adding further information.

Table 4. Structure of CIP-DOC

Psychosocial topic	1. PSG 2. PEC
Integrated data by psychosocial topic	1. Codebooks, questionnaires, and short survey reports 2. Documentation on PEC (e.g., standardized field/operation protocols, research, literature)
Result displays (e.g.)	1. Readable and portable files of codebooks, questionnaires and short survey reports 2. Readable and portable files of documentation on PEC (e.g., field/operation protocols, research, literature)
Overall content use/data upload/data base	- Static/manual/expandable
Additional remarks	- Download function, different search methods

The documentation page is a pure, static HTML with a list of cards showing information with the help of the Bootstrap library (Otto & Thornton, 2023). Each card shows a summary of the information; for a detailed view, the user has to click on the card. The information on the documentation page is stored on the server and can be updated, with each card displaying its update date. Furthermore, users can type terms they are searching for into an input field, with a meta data scheme in the backend. Running in the background and not visible for the user, a local search in the meta data or a global search using the texts themselves is also possible. In addition, CIP-DOC contains filters differentiated by psychosocial topic. For CIP-REP, as explained above, CIP-DOC delivers textual artifacts for expanding the domain ontologies used in the CIP-REP component.

USE CASES

CIP-PS addresses crisis managers, such as decision-makers from aid organizations, public authorities (e.g., the Red Cross or public health institutes), and government (small regions to federal states). Thus, CIP-PS is a decision support system for those directly working with the psychosocial situation in times of crisis and disaster. Furthermore, representatives from the media and academia as well as citizens at large can access CIP-PS for a descriptive overview of the situation. The following use cases show different applications of CIP-PS.

CIP-REP: Researching Variables and Concepts

In use case 1, the target group includes a researcher (RE) in the psychosocial field wanting to use our survey data for scientific purposes. These secondary data are collected and stored under the highest data protection and anonymity standards. RE is interested in the research question "Which factors are relevant for private emergency preparedness in a heat event?" and is guided by the protection motivation theory (Rogers & Prentice-Dunn, 1997) in which risk perception is key. As RE does not know what variables are in our dataset, they choose "risk perception" as a construct in CIP-REP (see *Figure 2*). If this variable exists, RE would like to know, what *category* it is in, the *wording of the question*, *values*, the *type of crisis*, and the *survey waves* the variables were measured for. According to *Figure 2*, RE's search can be narrowed to specific topics shown on the left. Moreover, the word cloud in the center as well as the filters on the left include specific characteristics to further narrow down the search, thereby bringing about results more effectively and efficiently. Upon completion of the search, the results display all the variables in our dataset matching the criteria RE has provided. Now, RE has a list of possible variables to analyze and could use our data for this purpose.

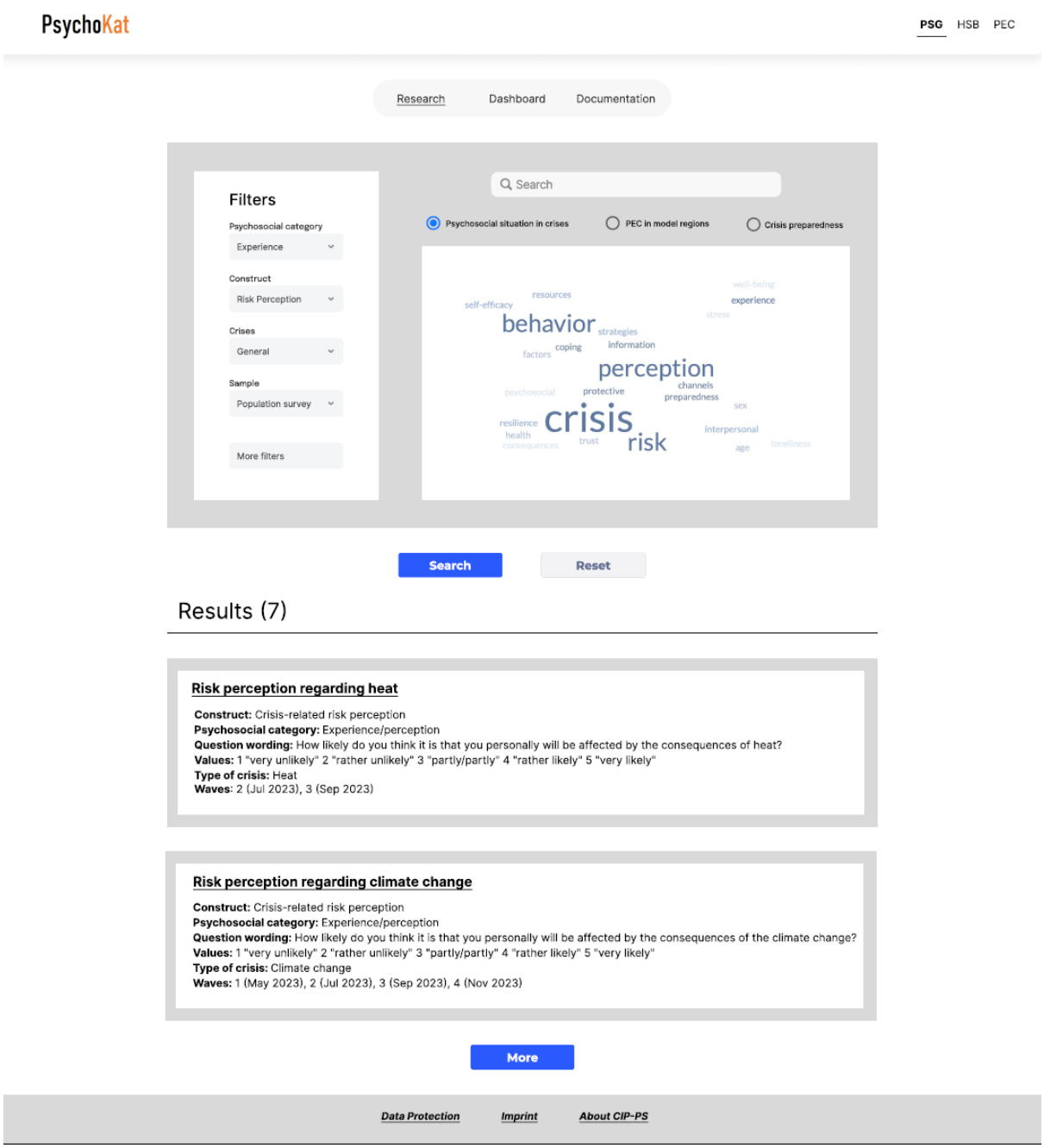

Figure 2. Screenshot of CIP-REP (use case 1)

CIP-DAB: Visualizing Risk Perception and PEC in Multiple Crises

In use case 2, the user is a crisis manager (CM) in an authority. CM wants to develop an effective risk communication strategy tailored to specific at-risk groups and is interested in the current state of the population so to be able to identify vulnerable groups (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe [BBK] & Bundesinstitut für Risikobewertung [BfR], 2022). To this end, CM searches for information shown on CIP-DAB, focusing on the risk perception of different population groups, differentiated geographically as well as historically. As shown in *Figure 3*, CM can select "Crisis-related risk perception" as a psychosocial variable to monitor. Also, CM is interested in age group as a risk factor in all German states. Furthermore, CM selects climate change out of all crises measured since May 2023 as a trend survey design. *Figure 3* shows the input fields, as well as a map with different values of risk perception by age group using a mouseover effect as well as a CI-plot and bar plot as visual controls (among other visuals such as a summary table of statistical values and a correlation matrix). Using the CI-plot, CM can tell if there are significant differences in mean values of risk perception between different age groups at one survey time and between different survey waves. Further, the bar plot includes absolute as well as relative frequencies of risk perception (using a mouseover effect) differentiated by age group and survey wave.

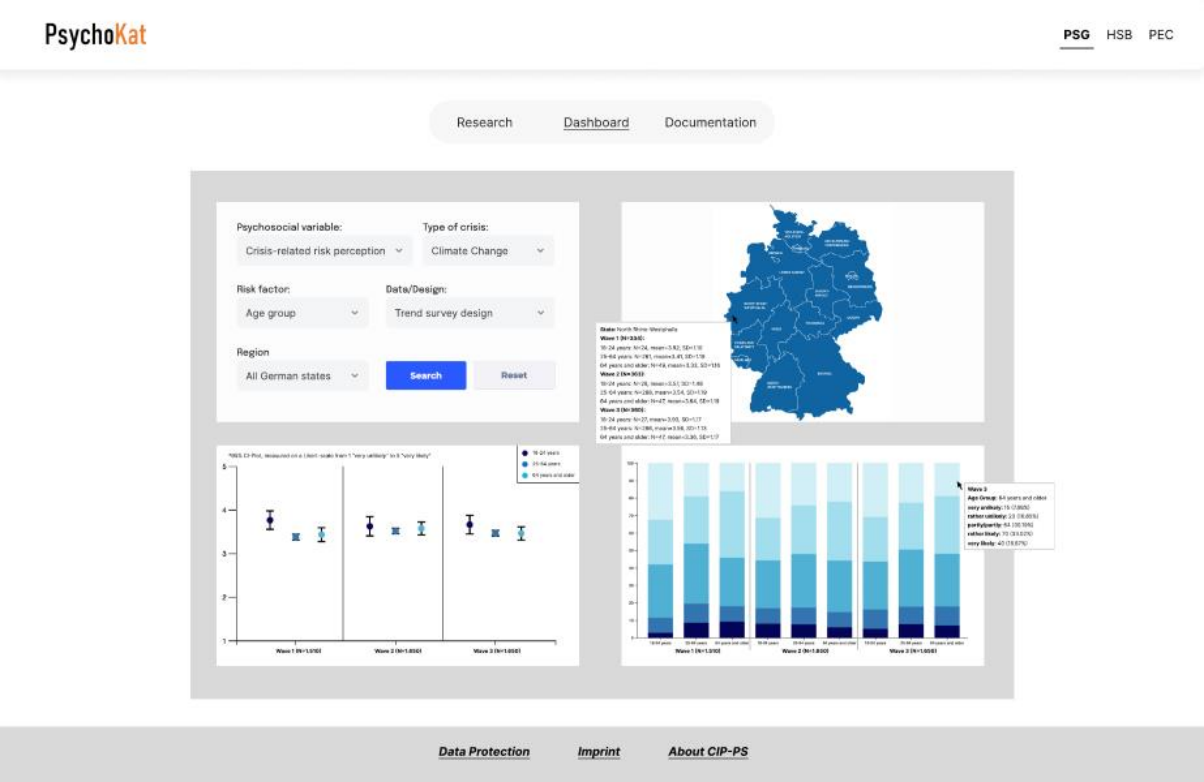

Figure 3. Screenshot of CIP-DAB (use case 2)

For the sake of clarity, we omit a figure for use case 3. Here, the head of the community level (HC) of PEC is interested in survey data on the knowledge about and personal usage of PEC in crises. The goal of HC is to advertise the service of PEC in these regions and to determine whether more resources are needed within the aid organization's structure. This information was measured for several model regions where PEC is offered by the aid organization. Thus, HC selects model region survey data in CIP-DAB obtaining the questions "Before participating in this survey, did you know what PEC is?" and "Have you ever used PEC from the respective aid organization in your region?" which will immediately provide HC with information that will help ground decisions on the investment of further resources.

CHALLENGES AND LIMITATIONS

Challenges

A general challenge is to accordingly align the technological development of the system components to the reuse of information substructures; namely, because joint patterns within the general information structure can be identified. For example, different ontologies, stemming from the three psychosocial topics (see *Figure 1* and *Table 2*), can share common concept spaces. Furthermore, common metadata sub-structures have to be identified and integrated accordingly.

One challenge of developing the dashboard is designing it as a micro frontend that has not been established yet. Its components were implemented using various libraries as shown above and function independently of each other. The great advantage of this micro-frontend architecture is that the dashboard can be deployed outside CIP-PS. The diagrams can also be deployed individually as a widget on a platform. This means that, for instance, the map would not cause a complete failure of the dashboard as happens with standard websites. The number of output diagrams can be expanded, and the individual diagrams can be built with different libraries.

A further design challenge is posed by the structuring and designing of the single elements within CIP-PS. The aim is for all elements to be customized to the needs of the user according to the highest standards of UI and UX. The platform should be easily understandable, handy, and user-friendly, so that the user (e.g., crisis managers, authorities, decision-makers) can obtain all the information they need and use it as a support system for their evidence-based decisions. At the same time, the principle of parsimony should ensure that using CIP-PS should not lead to information overload. For instance, an onboarding process with help texts would support this aim.

As concerns privacy regulations, the platform follows the principle of different user roles, meaning that it can be secured by using a safe login procedure. Further, all the data is stored on secure servers and is not available without permission.

As concerns data challenges, the data which is sent to CIP-PS and its individual components must be pre-processed. Using a data-centered approach, the national and model region survey PSG data is prepared and saved into single data files with a high number of possible combinations (e.g., different psychosocial variables by different risk factors). Data on PEC and HSB comprises studies and other documentation that have to be reviewed manually before saving all the information required for the different filters into differently structured tables.

The growth of "computing power, more complex algorithms and the availability of ever more potentially complimentary data online" (Quinn & Malgieri, 2021, p. 1583) means that the amount of sensitive data is increasing. This leads to social challenges, such as the need to protect sensitive data to prevent risks such as discrimination and harm to vulnerable groups in society. Naturally, there are high data protection standards when it comes to collecting survey data. This type of data is then also handled carefully, is anonymized and aggregated to make sure it cannot be traced to individual respondents, and is stored on a secure server. For the secondary use of the survey data, regional information such as postal codes or other identifying information about respondents is left out to ensure total anonymity, as a combination of only a few characteristics can potentially lead to identification (Bampoulidis & Lupu, 2019). For HSB, the individual underlying studies are not provided in the CIP-REP, but are freely accessible under scientific license conditions. The PEC literature is also freely accessible and no sensitive data, such as interview protocols, are stored in the CIP-REP or CIP-DOC. The PEC data for CIP-DAB consists of completely simulated data on protocols (no real data) in order to protect privacy, while the survey model region data is also aggregated and secured.

Limitations

Naturally, the development of CIP-PS is also subject to some limitations. Next, this section concerns limitations regarding the data of the psychosocial topics and general limitations in the technical development of CIP-PS and CIP-REP, CIP-DAB and CIP-DOC.

In terms of PSG, we have collected data in short intervals online-representative of sex, age, and German states, both as concerns the national situation as well as the three model regions. Although collected quite frequently, this data is nevertheless limited in time and space when it is integrated into CIP-DAB. Furthermore, the model regions were selected according to criteria on the occurrence of PEC teams, population size, and the number of single districts we can then apply multi-level models on. But these regions are not representative of all locations in Germany. Thus, we cannot monitor the psychosocial situation in (rural) regions, communities, or smaller

locations where disasters such as extreme weather events or wildfires (e.g., the flooding in Germany in 2021 or wildfires in 2023) occur. Moreover, CIP-DAB data only represents the German population, while disaster and crisis events happen all over the world, having more or less of an impact on the psychosocial situation of the population affected or involved. It would thus be essential to develop a cross-cultural international research network studying different perceptions and behaviors of the various populations in different or same crisis or disaster events.

In terms of PEC, only simulation data of operation protocols can be generated and integrated into CIP-DAB for data protection and security reasons. At this stage, it is not possible to process data from real people affected or involved in crisis or disaster situations. We will respond to this by developing an interface facilitating the connection between real data and CIP-DAB, with the aim of creating a framework with a full data protection scheme.

One limitation with respect to the technical development is that the data used by the components CIP-REP and CIP-DOC cannot be dynamically changed during system runtime. Thus, for example, artifacts such as questionnaires, studies, etc. have to be maintained offline. Furthermore, there are limitations in the development of the domain ontologies: first, the language expressivity of ontologies for CIP-REP is restricted to SKOS expressivity; second, new versions of ontologies cannot be dynamically added at runtime.

Although CIP-DAB is relatively flexible, there is a rather passive limitation when it comes to the resolution. That is, CIP-DAB is responsive in tablet mode only and is not necessarily suitable for mobile phones. Furthermore, CIP-PS and CIP-DAB both need an Internet connection when updating results. The PWA, however, as described above, helps keep recent searches stable before updating.

CONCLUSION AND OUTLOOK

In this paper, we described in detail the full development of our CIP-PS. In a first step, we introduced our conceptual foundation by explaining why it is important to monitor the psychosocial situation of the population during times of crisis and disaster, our systems thinking approach to increasing individuals' resilience, and which psychosocial topics need to be addressed. Thus, psychosocial aspects such as monitoring the situation to identify vulnerabilities in the population as well as summarizing studies on HSB and PEC information of aid organizations are crucial for drawing an overall picture of the situation. After explaining our two-stage research methodology approach, we presented a list of relevant recent platforms (see *Table 1*). This made clear the need for an information platform that follows a highly integrative approach.

Our main research question was: *"How can an information platform contribute to increasing the population's (psychosocial) resilience in times of crisis and disaster?"* The platform as IS delivers information to find correlations in different psychosocial data through an integration of different components. As both crises and the psychosocial situation are becoming more complex, the platform looks at statistical relationships in the data, reduces complexity and builds a system of systems (Cavallo, 2014, our three components) to model (psychosocial) reality at a manageable level. By integrating different components into the system of CIP-PS, it is thus possible to reach potential user groups from crisis managers to researchers and the public, thus fulfilling a policy need as well as responding to a research interest. Furthermore, spill-over, crowding-out, or habituation effects (Martin-Lapoirie et al., 2024; Weber, 2010) in different crises mean that there is a need to compare the concurrent behavior and perception of the population in multiple crises represented in CIP-PS. Other IS on surveys look at one crisis only (e.g., PACE, University of Erfurt et al., 2023), so that information has to be collected from different sources when developing action plans or communication strategies for the population at risk. Moreover, integrating different components improves statistical dependencies between them: thus when, for example, PSG in CIP-DAB shows that the elderly are more vulnerable in a particular situation, CIP-REP can help identify facilitators for appropriate HSB to further increase or restore the vulnerable group's resilience. Studies in CIP-REP, in turn, can lead to a derivation of new psychosocial variables to monitor in PSG. In conclusion, the different levels of complexity of crises and disasters make it difficult to identify people or population groups who are more or less vulnerable and foster or maintain their resilience accordingly – hence the need to monitor psychosocial consequences in the long run using an integrative approach of a system of systems.

The second question: "*How should an information platform be technically constructed so as to integrate different data types and connect different components with one another?"* addresses a technical aspect of the development of CIP-PS. We answered it by explaining the general concept of CIP-PS, its design framework (see *Figure 1*), as well as the technical functionalities concerning micro frontends, including the use of a PWA. We also gave a technical description of CIP-REP, CIP-DAB, and CIP-DOC.

We answered the third research question: "*How can different data be integrated and aggregated into a tool that researches, visualizes, and documents them?"* by describing the psychosocial topics and respective data each individual component integrates as well as how they display results and provide ways to edit and add further data into the systems (see *Tables 2–4*). Also, the functionality of CIP-REP and CIP-DAB was illustrated by three different use cases differentiated by user group, scenario, and data used, in order to show the diverse situations, the multi-functional crisis platform can be used for (see *Figures 2* and *3*).

While we have presented here a full development of our CIP-PS, we also want to mention future steps. First, additional national and model region survey data on several subsequent waves and short survey reports will be collected, processed, and sent to CIP-PS in order to expand all three components. The ontologies based on the data on PSG, PEC, and HSB will also be expanded to make the search using CIP-REP more efficient and effective. In addition, we plan further publications with both a theoretical and methodological focus (e.g., developing further the ontologies used or making the platform more responsive) in order to address gaps in the research.

In technical terms, the multi-modal system can be extended with respect to CIP-REP and CIP-DOC. In particular, integrative aspects like interlinking of semantically similar artifacts of CIP-REP and CIP-DOC could play a prominent role. Furthermore, an authoring element for all three CIP components and their related data could be established. Beyond the features of a classic Content Management System (CMS), this authoring element would support cooperative editing of, for example, codebooks, studies, or ontologies tailored to their individual structures. Further UI and UX improvements are planned for CIP-DAB.

All in all, we conclude that our CIP-PS addresses two major research gaps: first, based on the systems thinking approach and the knowledge transfer paradigm, it links different data on psychosocial topics together into one platform, thus reducing complexity. It helps the users systematically research, visualize, and document all the data, which is customized in favor of their needs and requirements, with the main goal of increasing resilience in the population. Second, CIP-PS proofs a full connection of a CIP-DAB visualization as well as a CIP-REP and CIP-DOC in both the frontend and backend, helping the users to obtain and visualize the information required as a decision support system. Hence, it is essential to present psychosocial data by topic independently as well as efficiently and effectively in the sense of a tool valuable for disaster public health and healthcare informatics.

ACKNOWLEDGMENTS

We would like to thank our research intern Lea Malcharczyk for her invaluable support in writing this article.

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